

Internationalization of corporate technology: an empirical analysis

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Internationalization of Corporate Technology: An Empirical Investigation*

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Introduction

The basic understanding of the internationalization of corporate activities can, albeit with the usual lack of subtlety, be reduced to a simple dichotomy in which some authors refers to the process of internationalization as corporate globalization in which firms become 'footloose', whereas others still understand the process of internationalization in terms of national companies that only partially increase their international activities without losing their national identity. A clear example of the first line of thought is found in Reich (1991) who portraits a situation of continuous globalization of corporate activities in which "...national champions everywhere are becoming global webs with no particular connection to any single nation (p.131)." Quite the opposite point of view is taken by Hu (1992) who argues that even though companies might have spread their operations over a number of countries most international companies still depend on their home-nation

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as a home market and a 'centre of gravity' for their activities. Amongst other things this author points at the share of turnover or production realized by international companies in each individual host country being much smaller than that of the country of origin.

Without entering into the debate at this stage, we would like to point at the necessity to understand the issue of internationalization not so much as a present state of affairs but much more from the dynamic perspective of industrial change. The main question does not seem to be whether companies are already operating at a truly international level but whether they are gradually becoming more international with respect to their foreign direct investment in both tangible and intangible assets, their internal and external technology flows, the internationalization of their financial organization, and their strategic linkages to other companies. If firms would gradually develop global strategies regarding for instance international manufacturing, intra-firm trade and many other aspects of corporate activity (see Dunning, 1988, Kobrin, 1991) their corporate innovative activities can be expected to follow this pattern at some distance. Such inter-temporal differences in the internationalization of various corporate activities are also mentioned in Cantwell (1991) and Pearce (1989) where it is argued that R&D tends to follow behind the establishment of manufacturing abroad with a certain time-lag.

In the literature the general advantage of an international R&D potential for companies is, as for instance mentioned by Pearce (1989), found in the ability "...to acquire a coordinated access to a wide range of innovative stimuli and sources of scientific creativity. To leading companies the assimilation of dispersed heterogeneous inputs into coherent creative programmes may be a major facet of a competitive global strategy" (Pearce, 1989, p. 5). Despite such potential benefits many companies still understand the issue in terms of a dilemma as argued in Casson (1991). On the one hand firms are drawn towards major international centres of innovation

in countries with relevant revealed technological advantages and on the other hand firms could have a preference to keep R&D as close as possible to their central office. In a similar vein de Meyer and Mizushima (1989) report some important changes in the internationalization of R&D by major firms, but these authors also stress that in many companies internationalization of R&D is only accepted with resignation.

Such arguments pro or contra the internationalization of corporate R&D can be associated with a discussion of the benefits of spatially concentrating R&D within the firm, see also Millar (1994) and Pearce and Singh (1992). Strictly taken concentration or dispersion of R&D is not identical to internationalization of R&D, but in particular for large, internationally operating companies one can expect a linkage.

Factors in favour of the dispersion of corporate R&D activities are:

- The transfer of knowledge to manufacturing facilities to increase local high-tech capabilities of subsidiaries.
- The interaction with high quality suppliers in innovative regions to benefit from particular technological advantages, which together with the previous factor can be summarized as the advantage of regionally concentrated technological competences, the so called agglomeration effect.
- The call for customization, responsiveness and adaptation to local market needs.
- Host government pressures and incentives to conduct locally or to maintain existing facilities.
- Reduction in the minimum economic size and divisibility of R&D facilities due to improved communication that allows for a more decentralized research capacity.

Factors in favour of concentration are:

- Economies of scope and scale in R&D that still exist within large facilities.

- The unstructured and intangible nature of R&D information demanding personal interactions.
- The necessary speed of decision-making regarding innovative projects.
- Shortened innovation cycles requiring shorter interface-distances.
- The need to protect and control product development as a major issue of corporate strategy close to the decision-making centre of the company, in short to have strategic control over technological development.
- The potentiality to capitalize on the accumulated experience in the home market and the technology networks with main supplies.

These factors suggest that, if corporate innovation is being internationalized at all, it will probably take place within a gradual development as pro's and con's are weighted in long term investment programmes. These different sets of factors also suggest that the issue is to some extent an empirical question as there is no a prior balance of the positive and negative effects of these factors. Therefore, in the following sections we will present some general indicators of the internationalization of corporate technology and assess the outcome of a number of empirical studies on the internationalization technological activity. The obvious research question we pose is to what extent companies have internationalised their innovation activities during the past decade.

This topic has both an academic and a policy-relevance. From an academic perspective it touches upon many issues that deal with our understanding of changing international market structures, national systems of innovation, the organization of international companies, the general internationalization strategies of firms, and eventually also the dynamics of economic and technological change. From a policy perspective it ties in with discussions about the relevance of national innovation policies in a period of

gradual internationalization of the economy and the possibilities for supra-national technology policies, for instance through the EC.

In order to study the research question introduced above in detail and to complement our general findings we have chosen the international information technology industry with subfields such as data-processing, telecommunications and microelectronics. Not only is this sector well established and characterized by a wealth of statistical data it also has a relatively long tradition of international competition that can substantiate our findings.

In the following we will first summarize some empirical evidence on the internationalization of corporate innovation for which we will follow the classical distinction between innovation input, i.e., companies' R&D efforts, and their innovation output, i.e., the patenting activities of companies. In addition to this we analyse recent data of European patents that enable us not only to complement some of the previous findings with data on the second half of the eighties and the early years of the eighties, but these data also generate some supplementary insight in foreign subsidiary patenting. International trends in strategic technology partnering, as found in a relatively large dataset, are analysed at some length in the following section. The subject of inter-firm strategic partnering receives a growing attention in the academic as well as in the more popular press. In that context joint technological development, supplementing intra-firm innovative activities, are mentioned as major mechanisms for improving the innovative capabilities and international competitive positioning of a growing number of companies (OECD, 1992). Increased world-wide competition, scarcity of innovative resources, the growing complexity of technological systems, global entry strategies, and world-wide simultaneous product introduction are mentioned as important motives behind these international partnering strategies. Given this growing importance of strategic technology partnering (Hagedoorn, 1993 and Hagedoorn and Schakenraad, 1993, Mytelka, 1991) both strategic technology partnering and the

international allocation of intra-firm research capabilities are important phenomena of which the understanding can add to our further appreciation of global corporate innovation efforts.

Our exploration ends with a brief expose highlighting the major conclusions that can be drawn at this stage.

Internationalization Trends in Corporate Technology

A number of studies on specific industries or samples of companies suggest that many multinational companies have gradually increased their foreign R&D efforts to between about one-quarter and a third of their R&D activities. As both Granstrand et al (1993) and Dunning (1994) recently presented overviews of the literature in this journal we will limit ourselves to a selection of contributions. Lee and Reid (1991) report that leading American companies in computers, telecommunications, microelectronics, pharmaceuticals and the automotive industry have increased their international R&D efforts to between about one-quarter and a third of their R&D activities. Warrant (1991) mentions an expansion of R&D by US companies in Japan, albeit from a very low level. Reich (1991) recounts an increase of 33% of overseas R&D of US companies between 1986 and 1987, compared with a 6% increase within the USA. Peters (1992) mentions the growth of the number of firms setting up new laboratories abroad. As far as leading US firms are concerned she estimates that about 20% of their R&D is located outside the USA. She also found that European companies spend a larger share of their R&D abroad than either the US or Japanese companies. Miller (1994) and Graves (1991) suggest that 25% of the research, development and engineering, i.e. a broader category than R&D, in the automobile industry is carried out abroad, which might be equivalent to about 15% of total R&D. Finally, in a study by Pearce and Singh (1992) on a large sample of 560 major internationally operating companies the growing role of internationalized R&D is stressed although it is also mentioned that global R&D is not yet a widely pervasive practice. The picture which emerges is that leading multinational companies have

indeed increased their foreign R&D to a level of about 10 to 20% of their total R&D, although considerably less in the case of Japanese companies.

For the evidence on innovation output in terms of patenting we can refer to a few studies. Patel and Pavitt (1991) have made an extensive analysis of the patenting activities of large companies. They distinguish patents taken out in the USA by 'national' companies in each country from those taken out by foreign subsidiaries of those national companies. They report that only for countries such as the Netherlands, Switzerland, the UK and Belgium does the number of US patents from foreign subsidiaries rise to a high proportion. Otherwise, the patent data confirm that although foreign subsidiaries of large companies do indeed contribute significantly to world inventive activities, this contribution was less than 10% of world patenting during the first half of the eighties. This leads Patel Pavitt to conclude amongst other things that "...in spite of considerable variations among large firms based in different countries, their technological activities remained far from globalised" (Patel and Pavitt, 1991, p.11).

In a somewhat similar line of research Cantwell and Hodson (1991) found higher shares of international patenting. They estimate the share of US patents attributable to research in foreign locations for the world's largest firms during the first half of the eighties at about 10%. These differences are largely due to the fact that Patel and Pavitt include small and medium companies, universities and government laboratories in the denominator of the total of patents, whereas Cantwell and Hodson limit their total population to patents granted to the group of largest companies. However, also their research only indicates "...that the world's largest firms witnessed a mild trend towards the internationalization of technological activity over the 1969-1986 period ..." (Cantwell and Hodson, 1991, p. 137). They certainly do not suggest of a sudden explosion of globalization of innovation during the seventies and the first half of the eighties.

To a certain extent following Patel and Pavitt (1991) and Cantwell and Hodson (1991) we perform a somewhat similar analysis to detect a possible continuation of trends in the internationalization of innovative output, measured by patents, comparing patenting activity in two periods, i.e., 1980-1985 and 1986-1991, extending the period of analysis to the late eighties and early nineties. Instead of using data from the US Patent Office, as done in the previously mentioned studies, we compiled our data from the European Patent Office (EPO). We chose to focus on EPO patents because it enables us to evaluate the internationalization tendencies of corporate technological activities from a different (European) perspective. Whereas the US patent office data seems to be somewhat biased towards US companies, the EPO data is expected to be biased towards European companies. This bias is however lower than the bias of national patent offices (OECD, 1993). As with US patent data, the EPO data allows us to differentiate between the applicant and the inventor, which enables us to discriminate between the total number of patents that were filed by institutions from a specific region and the percentage of those patents based on inventions from outside that specific region. We calculated these percentages for the whole population irrespective of size and institutional form. In our opinion this is a more precise representation of the overall importance of internationalization of technological activities at large than restricting our analysis to large firms only.¹ In our analysis we compare internationalization patterns for three major regions: Europe, Japan and the USA.

Because our analysis includes the whole population of patenting organizations and because our data is not consolidated by ownership we expect the overall degree of internationalization of technological activity to be somewhat below the findings of Patel and Pavitt (1991) and Cantwell and Hodson (1991). This expectation is confirmed by our findings on the internationalization of technological activity, see Table 6.1. Overall only 6.6% of patents filed with the EPO by US institutions were registered with

inventors outside the US. For Europe and Japan the figures were even lower, only 2.9% of European patents were invented outside Europe, whereas Japan lags behind the internationalization process with a modest 0.7%. The major differences between our findings and those of the other contributors can be attributed to the fact that we aggregated our data at an European level. This implies that the internationalization patterns for European firms found by Patel and Pavitt and Cantwell and Hodson probably largely refers to intra-European internationalization. It seems that extra-European internationalization of technological activity of European firms is found only in a relatively small number of cases (Table 6.1).

Table 6.1: Foreign Subsidiary Patenting as a % of Total EPO Patents, 1980-1985 and 1986-1991

	<i>Total</i>		<i>IT Total</i>		<i>Computers</i>		<i>Micro</i>		<i>Telecom</i>	
	80-85	86-91	80-85	86-91	80-85	86-91	80-85	86-91	80-85	86-91
Europe	2.6%	3.0%	2.0%	2.0%	3.2%	2.3%	1.3%	1.6%	1.5%	2.0%
US	6.8%	6.4%	8.0%	6.0%	7.2%	6.4%	6.4%	5.1%	11.7%	6.1%
Japan	0.7%	0.8%	0.4%	1.4%	1.0%	2.1%	0.1%	1.3%	0.5%	0.8%

Source: European Patent Office.

A comparison of the periods 1980-1985 and 1986-1991 shows that only slight differences are found. In general Europe and Japan demonstrate a small increase in internationalization. The US on the other hand experienced a slight decrease in international patenting. For the information technology industry we found a slightly different picture. The US Leads the internationalization process in all segments but suffered a clear drop from 8.0% in the first period to 6.0% in the second period. Although for the US the percentage of international patents fell in all information technology segments, this decrease can be primarily attributed to a decrease of 5.6% in the telecommunications industry.² International technological activity of European institutions outside Europe remains at 2.0% of total patents. Europe's percentage seems to rise in telecommunications and microelectronics but decreases

in data-processing. Japan on the other hand shows an increase in all three segments. Apparently an industry that is often referred to as 'globalized' is found to be not very internationalized in terms of its technological activities. All this suggests that the moderate trend towards internationalization of technology found by Cantwell and Hodson (1991) has not accelerated during the second half of the 1980s and early 1990s.

Trends in the Internationalization of Strategic Technology partnering

Given the modest degree of internationalization of firms' innovative activities, an interesting question would be to find out whether corporate strategic technology partnering demonstrates similar or dissimilar international patterns. In previous work it was already established that during the 1980s strategic technology partnering increasingly became more important to the innovation strategies of a large number of companies (Hagedoorn and Schakenraad, 1992 and 1993). Such strategic technology partnerships are to be understood as inter-firm agreements for which joint R&D and/or other innovative activities are a major objective and that can reasonably be assumed to affect the long-term product market positioning of at least one partner. Joint ventures with shared R&D resources, R&D corporations, joint R&D pacts, cross-licensing agreements, research contracts and second-sourcing agreements are clear examples of this category of inter-firm cooperation.

In the literature, see for instance Ohmae (1990) and de Woot (1990), it is sometimes suggested that strategic alliances are essential to international corporate strategies. Although we refer only to strategic technology alliances we think that in general internationalization is not the sole objective of strategic alliances. For many technology partnerships improving the innovative capability of at least one of the partners will be a major objective. This objective will frequently coincide with an internationalization or globalization strategy of the company but it could fit equally well within a domestic or more regionally concentrated

strategy. Most of the arguments pro or contra the internationalization of corporate R&D also bear relevance on the international partial externalization of innovative activities through inter-firm partnerships. The bottom line of the argument would be that there is a clear tension between international partnering benefitting from 'foreign' capabilities and a larger degree of control through alliances that are closer to the 'domestic' span of control. We assume that joint R&D is closer to the corporate core of most companies than the sharing of certain production facilities or the joint entry of uncontrolled foreign markets. Therefore we can expect that the internationalization of R&D through international strategic technology alliances will still be at a moderate level compared to partnerships which are more directly related to market entry arrangements and joint production.

Based on such notions of corporate internationalization we can formulate two topics for further research:

- *First*, if strategic technology partnering has increased in recent years the question emerges whether this increase has been of a primarily international character or whether companies are predominately searching for partnerships with companies from the same economic region,
- *Second*, we expect strongly international oriented inter-firm alliances to be more concentrated on commercial activities whereas R&D focussed alliances are probably of a less international character.

Before we enter into the subject of particular patterns of the internationalization of strategic technology partnering we will first briefly sketch the broader picture of overall trends as found in the MERIT-CATI databank, *see* Appendix 6.2. In Fig. 6.1 we present the flow pattern of newly established partnerships during the 1980's. This figure clearly shows that the growth pattern is quite different if one compares the overall trend with information technology and the three subfields that we analyse in this paper. The overall growth pattern demonstrates a strong increase of newly made alliances during the mid-eighties, after which increase of new alliances is still strong but somewhat less

prominent during the later years of the decade. The trend for the total of information technology alliances, that account for about 40% of the entire population, appears to be somewhat different. Here we notice a strong increase during the first half of the eighties, after which the growth pattern is first stabilized until it increases again in 1988 and 1989. For sub-fields of information technology we see a somewhat fluctuating pattern during the 1980s.

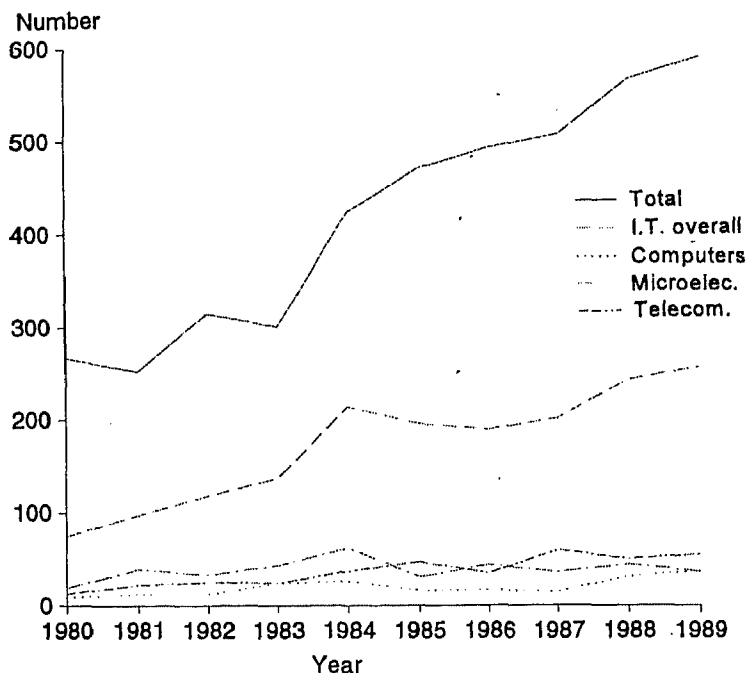


Fig. 6.1: Growth of newly established strategic technology alliances in all fields, total informations technology, and computers, microelectronics, telecommunications, 1980-1989.

The next step in our analysis is to find an answer to the research questions introduced above and to see whether inter-firm strategic technology partnering is characterized by a truly international pattern. It seems therefore interesting to consider whether the increase in cooperative activity has been of a primarily international character or whether companies are predominantly searching for

partnerships with companies from the same economic region. Table 6.2 shows the distribution of strategic technology alliances within and between economic blocks in two time periods (1978-85, 1986-93). For the total number of IT alliances the relative importance of inter-region alliances shows a decrease from 46.2 per cent in the first period to 34.7 per cent in the second period. The largest

Table 6.2: Distribution of Strategic Technology Alliances within and between Economic Blocks, Percentages, 1978-85, 1986-93

	<i>Total</i>		<i>Computers</i>		<i>Telecom</i>		<i>Semiconductors</i>	
	1978-85	1986-93	1978-85	1986-93	1978-85	1986-93	1978-85	1986-93
USA-EUR	21.2	18.0	24.2	16.1	20.5	22.6	20.7	26.4
USA-JAP	21.5	13.5	21.9	19.7	14.6	5.2	32.9	30.5
JAP-EUR	3.5	3.2	7.0	4.0	2.6	3.0	3.2	6.1
EUR-EUR	21.0	14.9	14.8	7.2	26.5	22.6	13.1	13.8
USA-USA	27.3	42.4	25.8	45.8	28.5	35.1	25.7	19.3
JAP-JAP	5.5	7.9	6.3	7.2	7.3	11.7	4.5	13.8
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

drop in inter-regional alliances is found in the computer industry. In this industry international alliances accounted for more than half (53.1%) of the total number of alliances in the first period but showed a decrease to 39.8 per cent in the second period. The decreases in the relative importance of inter-regional alliances were significantly lower in other IT sectors. Decreases in the other sectors range from 7 per cent in telecommunications to 4 per cent for semiconductors. Although these decreases are significantly smaller than the decrease in the computer industry they confirm that alliances are not the vehicles for internationalization they were thought to be.

The data from the MERIT-CATI database until 1989 also enables us to differentiate between strategic technology alliances that are primarily related to R&D and alliances that, despite their technology content, are also undertaken to access markets or to produce or market specific products. This distinction enables us to assess whether R&D-inclined alliances are undertaken by companies within a certain

region and whether market oriented technology alliances have a more international character. In order to reveal patterns of internationalization we will introduce a new measure of relative internationalization which we calculated by setting the ratio in intra-regional partnering against the ratio for inter-regional partnering for each sector³ (see Table 6.3). This confirms our expectation that market oriented alliances are more international than more R&D focused alliances. All the sectors with the exception of telecommunications show a strong decrease in the degree of internationalisation during the second half of the 1980s. The overall pattern therefore suggests that, despite some sector specific and/or international irregularities, strategic partnering has become relatively more concentrated within major regions of the Triad instead of becoming overwhelmingly international.

Table 6.3: Relative Internationalization Index of Strategic Technology Partnering in Overall Information Technology,⁴ Computers, Semiconductors and Telecommunications, 1980-1984 and 1985-1989

	<i>R&D</i>		<i>Market</i>	
	1980-84	1985-89	1980-84	1985-89
Total	0.88	0.66	2.49	1.69
Computers	1.35	0.66	2.45	1.52
Micro	1.07	0.7	3.87	1.75
Telecom	0.93	0.85	1.4	1.42

In other words, the overall pattern suggests that, despite some sector specific and/or international irregularities, strategic technology partnering has become relatively more concentrated within major regions of the Triad instead of becoming overwhelmingly international.

Conclusions

In this chapter we explored some recent trends in the internationalization of corporate technological activities. This issue is typically caught within the dichotomy of

benefits that accrue from the international externalization as well as the internal dispersion of innovation processes. On the one hand firms are drawn towards major international centres of innovation in countries with relevant revealed technological advantages and on the other hand firms have a preference to keep R&D as close as possible to their headquarters. We suggest that companies are likely to perform a critical evaluation of the advantages and disadvantages of a further internationalization of their technological activities. Firm specific innovative capabilities, sectoral specificities and country-specific technological advantages play a role in this process of internationalization.

The results of our analysis imply that companies are yet far from global in terms of the internationalization of their technological activities. Also a probable 'footloose' character of multinational firms with a global research base is not supported by the present investigation. On the contrary, for the by far larger part, companies appear to rely extensively on home country or nearby research facilities. In general, corporate innovative activities are still primarily of a local or regional character. As far as the importance of strategic technology partnering of companies is concerned our main findings suggest that, despite an overall increase in strategic technology alliances, this phenomenon has become relatively more concentrated within major economic regions instead of becoming overwhelmingly global. A comparison of R&D and market-oriented technology partnerships revealed that most of the R&D directed alliances are found within economic regions while the majority of the market oriented alliances are of a more international character.

In this chapter we stress that internationalization should not be seen as a static phenomenon but much more viewed from a dynamic perspective. Therefore, the main question is not whether companies are already innovating globally at a large scale but whether they are gradually becoming more internationalized in their innovative activities and capabilities. The answer to this question

appears to be that both the internal aspects of corporate innovation processes as well as the joint research activities of firms suggest a moderate increase in the internationalization of corporate technological activities and certainly not a sudden explosion of globalization during the past decade.

An explanation for 'regionalized' patterns of internationalization of both internal innovative efforts and joint R&D through strategic alliances can be found in the organizational complexities that surround these particular aspects of company organization and corporate strategies. The international coordination of production, servicing, sales and marketing already creates substantial organizational complexity for companies operating beyond their domestic markets. The internationalization of corporate R&D and other innovative activities, such as product development, with companies attempting to benefit from the internationally uneven distribution of technological capabilities through an innovative presence beyond their domestic markets, creates additional aspects of complexity in international strategies and company organization. This organizational complexity and the risk of organizational failure probably explains why international inter-firm R&D collaboration is still of a strong regional nature, i.e., to a large extent concentrated within each of the major trading blocks, and why the internationalization of corporate innovation is, although by no means insignificant, still quite moderate. It appears quite rational that many firms limit themselves to a more internationally regional strategy with only moderate extension beyond their region of origin. That particular option largely coincides with an international strategy that represents a compromise between a domestic and a global strategy with still sufficient scale effects and ample opportunities for capitalizing on regionally available technological competences.

Appendix 6.1: Explanation of Patent Allocation Procedure

Research on the patents of 50 leading information technology companies in the period 1980-1994 (see Appendix 6.1) demonstrates out that foreign subsidiaries of these companies account for only a very small percentage of the number of total patents of these companies. Information on the subsidiaries of the 50 leading companies was gathered on a year to year basis through annual reports and multiple volumes of 'Who owns Whom'. In our analysis we included a total of 195 of the largest subsidiaries of these 50 leading firms. 49 out of these 195 subsidiaries could be considered as foreign subsidiaries. From a total of 94,660 applied patents of the 50 companies only 751 were applied for by foreign subsidiaries. Hence, foreign subsidiaries account for less than 1 per cent (0.79%) of all applied patents.

Sample of 50 leading companies to determine the rate of foreign subsidiary patenting

AMD	NEC
AT&T	NT
Alcatel	NTT
Amdahl	National semiconductor
Apple	Nokia
Ascom	Oki
Bosch	Olivetti
Bull	Philips
CDC	Racal
Canon	Ricoh
Compaq	Rockwell
DEC	SGS/Thomsom
Ericsson	STC
Fujitsu	Sagem
GEC	Samsung
GTE	Sanyo
H-P	Seagate

(Contd. ...)

Hitachi	Sharp
IBM	Siemens
Intel	Sony
Matra	TI
Matsushita	Toshiba
Mitsubishi	Unisys
Motorola	Wang
NCR	Xerox

Appendix 6.2: The Cooperative Agreements and Technology Indicators (CATI) Information System

The CATI data bank is a relational database which contains separate data files that can be linked to each other and provide (des) aggregate and combined information from several files. So far information on nearly 10,000 cooperative agreements involving some 3500 different parent companies has been collected. Systematic collection of inter-firm alliances started in 1987. Many sources from earlier years were consulted enabling a retrospective view. In order to collect information alliances various sources were consulted, of which the most important are newspaper and journal articles, books dealing with the subject, and in particular specialized journals which report on business events. Company annual reports, the Financial Times Industrial Companies Yearbooks and Dun & Bradstreet's 'Who Owns Whom' provide information about dissolved equity ventures and investments, as well as ventures that were not registered when surveying alliances.

This method of information gathering which one can refer to as 'literature-based alliance counting' has its drawbacks and limitations due to the lack of publicity for certain arrangements, low profile of certain groups of

companies and fields of technology. Despite these shortcomings, which are largely unsolvable even in a situation of extensive and large-scale data-collection, we have been able to produce a clear picture of the joint efforts of many companies. This enables us to perform empirical research which goes beyond case studies or general statements. Some of the weaknesses of the database can easily be evaded by focusing on the more reliable parts, such as strategic alliances.

The data bank contains information on each agreement and some information on companies participating in these agreements. The first entity is the inter-firm cooperative agreement. We define cooperative agreements as common interests between independent (industrial) partners which are not connected through (majority) ownership. In the CATI database only those inter-firm agreements are being collected, that contain some arrangements for transferring technology or joint research. Joint research pacts, second-sourcing and licensing agreements are clear-cut examples. We also called information on joint ventures in which new technology is received from at least one of the partners, or joint ventures having some R&D program. Mere production or marketing joint ventures are excluded. In other words, our analysis is primarily related to technology cooperation. We are discussing those forms of cooperation and agreements for which a combined innovative activity or an exchange of technology is at least part of the agreement.

Notes

1. Although we are aware of the possible biases that are associated with this analysis we did not consolidate the data by ownership. Research on a relatively large sub-set (50 large companies) indicates that in virtually all cases parent firms did apply for all patents that were invented by their subsidiaries. For a comparison of countries and changes over time consolidation seems to affect our results only marginally, see Appendix 6.1 for the procedure followed.
2. This drop could well be the result of the divestiture of large parts of ITT's European telecom subsidiary to Alcatel in 1986.

3. This relative internationalization index (RII) is calculated per sector as the relative distribution of the inter-regional alliances (IA_i) set against the number of intra-regional alliances (RA_i):

$$RII_i = \frac{IA_i}{RA_i}$$

4. The index for the overall information technology includes software and industrial automation.

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